# ENHANCED NUCLEAR ENGINEERING SIMULATORS (ENES)

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## INTRODUCTION

Engineering simulation is a sophisticated multi-purpose technology allowing the users of simulators to run a variety of engineering activities due to the possibility of modifying the simulated plant architecture and components, to adjust parameters, to test alternative solutions.

Engineering Simulators (ES) have been built and used worldwide for a variety of purposes:

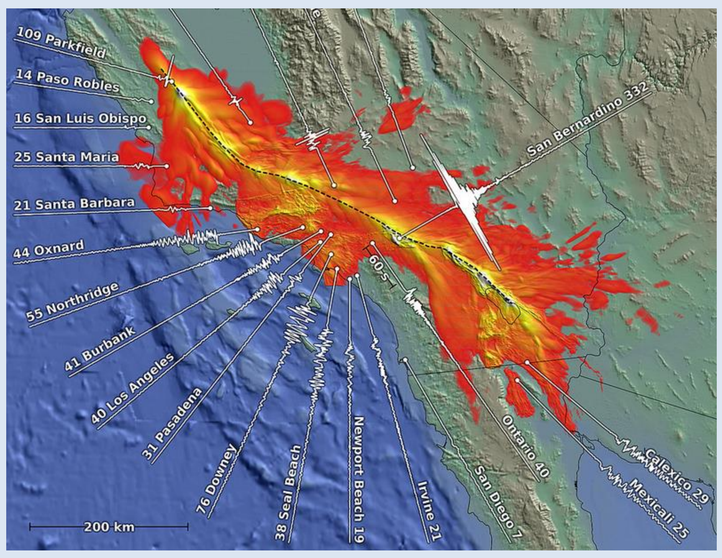
- Development and refinement of the plant design or plant modifications
- Safety analyses focused on the overall system behaviour
- Verification and Validation (V&V) of systems and components
- Development of Operational and Emergency Procedures
- Pre-Training of operators and supervisors
- High level education and Communication activities
- Human Factor Engineering Analysis
- Adaptive Control System training

Engineering Simulators also play a role in developing and maintaining key nuclear skills, as knowledge repositories and tools for training at various levels of expertise.

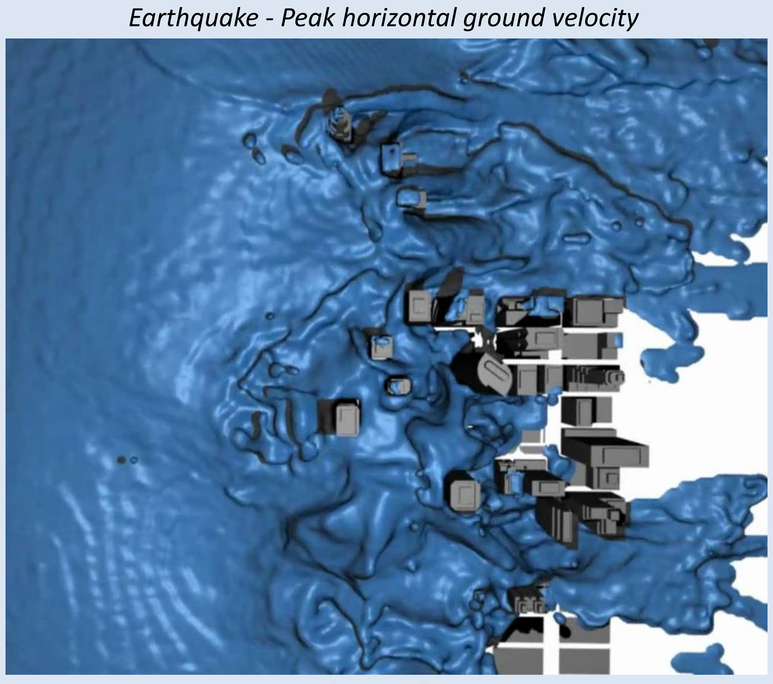
## OBJECTIVES

The **ENES** Strategic Project is to design in detail the desirable improvements to the current generation of Engineering Simulators for Gen II – Gen III NPPs in order to define a new generation of **Enhanced Engineering Simulators** that respond adequately to the issues raised by the Fukushima accident and other key targets of the international agenda for nuclear plants safety.

The need of research derives from the analysis of the stress tests and the subsequent ENSREG recommendations focusing on a deeper consideration of **extreme natural events** in the **design** and **safety verification** of NPPs.




*Earthquake - Peak horizontal ground velocity*



*Tsunami – 3D simulation of water propagation*

## ENES CONCEPT

The objective will be achieved through the definition of an innovative simulation architecture including both **classic** models categories and **innovative** software models for:

- simulating extreme natural events,
- predicting the dispersion of radionuclides in the environment,
- calculating their potential effects on population.

The domain of analysis of the simulator is enlarged:

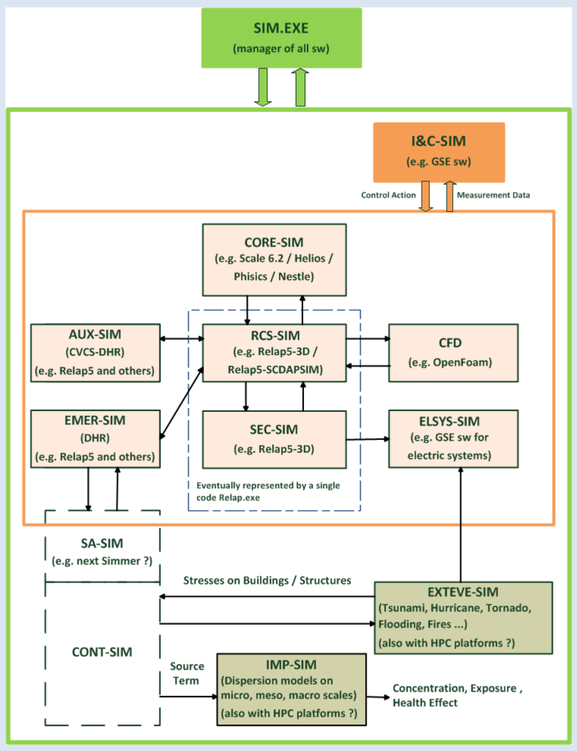
**Main Systems & Buildings of one Reactor** → **Whole NPP Extension & Surrounding Territory**

Increasing computation speed beyond real time will also allow using ENES as a **Decision Support Tool**, when decisions can be eased by fast and accurate analysis of alternative action consequences.

The innovative concept will be turned into a first **prototype of Enhanced Simulator**, which will be demonstrated through case studies based on a real LWR under operation.

The demonstration will be realised through an advanced hardware platform based on:

- *NUTEMA* - Knowledge Management and Simulation System, Pisa University
- *CRESCO* - High Performance Computing System, ENEA




## ENES PRELIMINARY ARCHITECTURE

The definition of the **Enhanced Simulation Architecture** (ESA) will include both macroscopic aspects and much more detailed ones such as the definition of the best alternative software models to be used, the metadata to be exchanged among these software tools, the relationships between some of these models and a Geographic Information System (GIS) or with a High Performance Computing (HPC) platform.

The definition of the Enhanced Methodology will allow the selection of a variety of **alternative software tools** available worldwide for covering the **extended functions** of the ESA, since ENES strategic project doesn't aim at defining a single specific architecture that can be realized only with a given set of software models.

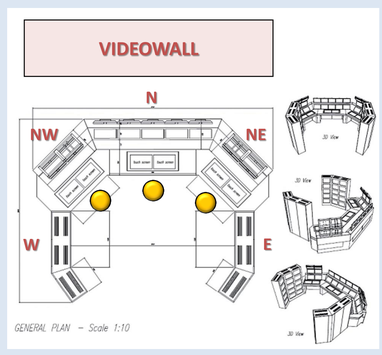
The preliminary scheme of a possible software architecture reflects the key idea of identifying systematically the **classic** and **innovative** simulation areas, by putting together classic competences in the nuclear field, simulation technologies, environmental aspects, weather phenomena and other extreme natural or man-induced dangerous events.

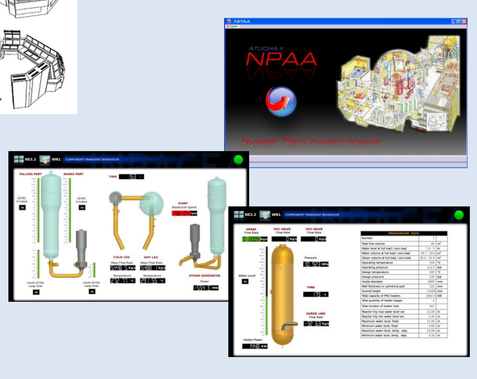
## NUTEMA

### Knowledge Management and Simulation System

ENES will take benefit from the experience gained by the University of Pisa and NINE in the design, development and operation of NUTEMA platform, a powerful system for Knowledge Management and Advanced Simulation. The facility worth over 1 M€ and will be made available for demonstration activities of the ENES project. The below reported pictures show the NUTEMA system during a simulation work on a Nuclear Power Plant for Licensing purposes.

This relevant hardware and software platform shows excellent human-machine interface and visualisation possibilities. With these characteristics NUTEMA is seen as the ideal system for an enhanced engineering simulator.




## CRESCO

### High Performance Computing System

ENES will identify innovative solutions for future Engineering Simulators also by exploring the opportunities offered by High Performance Computing (HPC) technologies, which can significantly contribute to the implementation of sophisticated and time consuming software tools, thus allowing the application of the future simulators also as Decision Support Tools during Plant Operation when the 'faster than real' capability is a key requirement.

In recent years a major computing centre was established in Portici (Naples), where currently the CRESCO HPC facility is hosted. The CRESCO HPC facility, owned by ENEA, was recently upgraded, which allowed a substantial increase in available computing power, currently around 150 TFlops.

## CONCLUSIONS

ENES strategic project is situated in the Horizon2020 spectrum 'from idea to application'. The project will start with the detailed methodological definition of how to materialize an ambitious Project Idea generated and proposed within NUGENIA Association, while the full commercial exploitation of project results will follow project conclusion.

The latest outcome of the project will be the building of a prototype of **Enhanced Engineering Simulator** and the running of a Demonstration study for showing the feasibility of the project key ideas.